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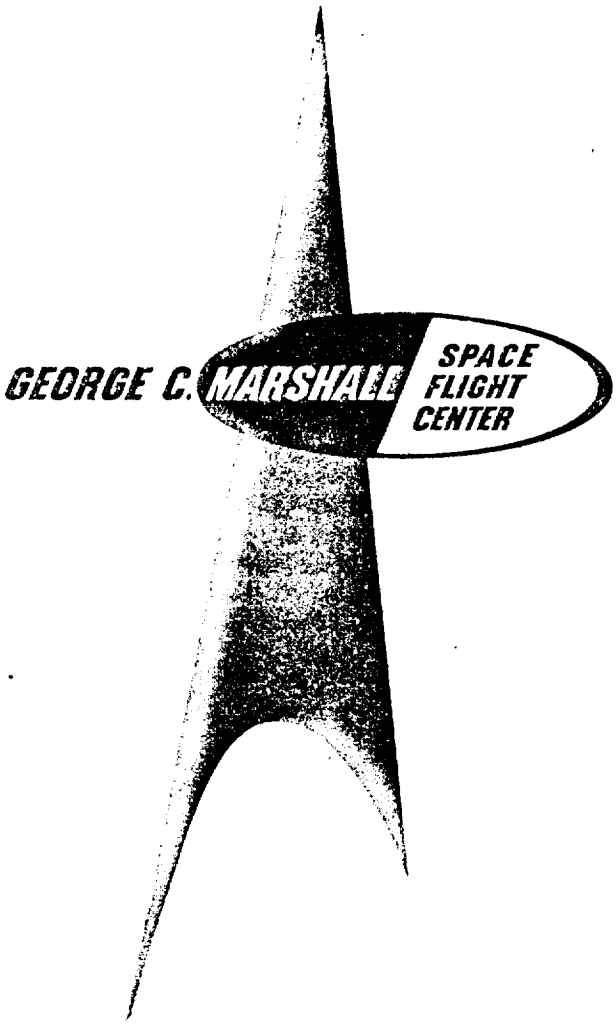

FAILURE ANALYSIS OF STRUTHERS - DUNN S2GP-7.25-73D RELAY

(NASA-TM-109263) FAILURE ANALYSIS OF STRUTHERS-DUNN S2GP-7.25-73D RELAY (NASA) 25 p

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I. INTRODUCTION

One Struthers-Dunn relay, part number FC-1-188, type number S2GP7.25-73D, manufactured to MSFC-SPEC-339/73D, was received by this laboratory for failure analysis. The date code is 7643. This relay had been installed in the Range Safety Command Decoder, S/N 402, by AVCO. After dynamic shock testing the decoder would not respond with an output signal in Command number 1 under proper interrogation.

The decoder had passed all Shuttle single mission qualification testing except shock and EMI tests when the failure occurred. The unit was being shock tested at MSFC and subsequent to failure, checks of the shock test set up revealed an "overstressed test condition" with transmissabilities as high as ten (10) times the test limit.

II. PURPOSE

The purpose of this analysis was to attempt to determine the cause of failure of this relay.

III. ANALYSIS

The relay was radiographed, but this did not reveal any out-of-spec conditions.

The relay was then mounted on a printed circuit board for complete electrical tests. During electrical test, a momentary open coil condition was noted which prevented operation of the relay contacts. Test personnel stated that the open coil condition was not observed during testing in the decoder. assembly.

The part was then removed from the printed circuit board and during removal, pin number 19 came out of the relay header. It was noted that the glass seal around pin 19 as well as some other seals were cracked.

Extensive testing was performed to determine if a problem existed with the glass seals in this lot of relays. It was determined that there was not a seal problem and that the cracks in the failed relay were most probably caused by the overstressed shock testing or by removal of the relay from the decoder assembly.

During the microscopic examination, a particle was noted between the armature and pole piece, preventing the armature from moving. Figures 2 and 3 show the location of the particle. Upon retrieval of the particle it was found that there were actually two particles magnetically attached to each other and to the armature.

The particles were examined with the scanning electron microscope and an EDAX analysis performed. It was determined that the primary constituents of the particles were iron and nickel. Figures 4, 5, 6 and 7 show the particles and the EDAX results. Because of the irregular surface of the particles, it was concluded that they were most probably generated from welding operation during assembly of the relay. Through further analysis, it was determined that the same materials were used in the pole piece and backstop; therefore, it was further concluded that the particles were most probably generated during welding this assembly. Figures 8, 9, and 10 show the pole piece-backstop assembly and the EDAX results of each.

Another observation made during the microscopic examination was improper weld of the coil lead to pin 19. This is shown in figure 11. Figure 12 shows the opposite coil lead attached to pin 20. This was a good connection. The coil lead from pin 19 was straightened so that the pin contact area could be observed. Figure 13 shows this area. An EDAX analysis was performed in two places in the contact area as shown in figure 13, with the results shown in figure 14, and a reference analysis on the back of the lead at the contact area as shown in figures 15 and 16. There was no indication of pin material in the pin contact area indicating that the lead had not been properly welded to the pin.

The pin was examined for any indication of weld penetration but none could be found as shown in figure 17. This figure shows two views of the pin taken 180° apart.

The other coil lead and pin 20 were removed from the relay to observe the weld. Figure 18 shows the pin and lead prior to removal and figure 19 shows the lead-to-pin weld. Upon pulling the coil lead from the pin, the lead broke at the heel of the weld as expected, indicating good weld penetration.

Nineteen additional relays from this lot were examined and further analyzed to determine if the anomalies observed in the failed relay were lot oriented. Figure 20 shows scratches inside the case of serial number 10. A particle was observed in this relay attached to the inside top of the case. This particle is shown in figure 21 and the EDAX results are shown in figure 22. It was determined that this particle was the same material as the case and was generated when the case was fitted to the relay assembly.

Thirteen new relays from AVCO stock were subjected to Particle Impact Noise Detection (PIND) tests. Of these, four indicated particles. These four relays were tested electrically with satisfactory results. They were then opened for examination. Following is a list of observations of these relays:

Serial No. 22	1. Residue spots in top of case, figure 23 2. Small non-metallic particles in case, figure 23 3. Particle attached to armature next to pole piece, figure 24

Figure 25 shows the particle and figure 26 is the X-ray spectrum.

Serial No. 24	1. Copper colored particle in top of case, not attached, figure 27 2. Small non-metallic particles in case, figure 27 3. Metallic particles magnetically held to pusher, figure 30

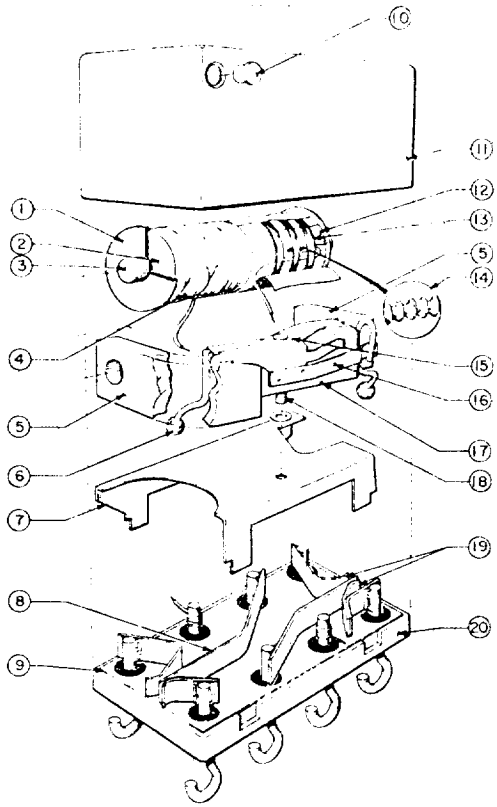
Figure 28 shows the copper particle and figure 29 is the X-ray spectrum.

Serial No. 30	1. Minute particles in top of case 2. Metallic particles magnetically held to pusher, figure 31
Serial No. 45	1. Numerous non-metallic particles in case, including one fiber approximately 3/4 inch long, figure 32 2. Armature very loose with excessive end play. The spring was not contacting the armature pivot bearing, figure 33

IV. CONCLUSIONS

It is concluded that the failure of the relay in the Command Decoder was caused by particles magnetically attached between the armature and pole piece thus restricting the movement of the armature thereby preventing movement of the contacts. It is further concluded that an improper weld existed between pin 19 and the coil lead and that this connection caused intermittent operation of this coil. The cracked glass seals were most probably caused by either the excessive shock or the removal of the relay from the decoder assembly.

Based upon the results of the examination of other relays from the same lot it is concluded that serious contamination conditions exist in this lot of relays. The relay vendor's quality controls should be reviewed for adequacy.



ITEM	ITEM NAME
1	Bobbin
2	Magnet Wire
3	Core
4	Insulating Wrap
5	Pole Piece
6	Pusher
7	Frame
8	Movable Contacts
9	Insulation Pad
10	Plug
11	Case
12	Insulating Film
13	Insulating Thread
14	Reinforcing Lead
15	Back Stop
16	Return Spring
17	Armature
18	Pivot
19	Stationary Contacts
20	Header

Figure 1. Typical Armature Relay Design

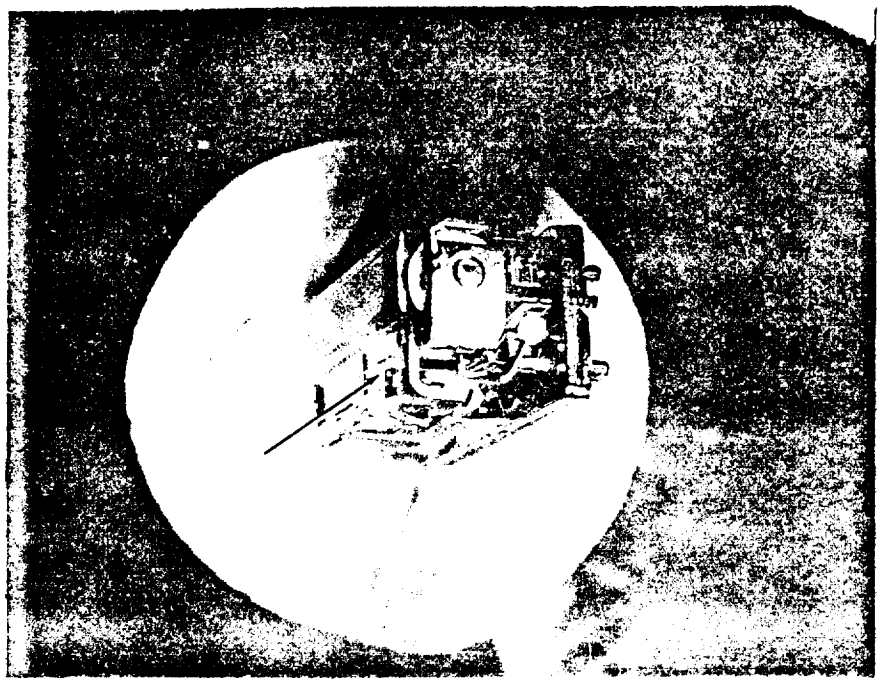


Figure 2. Relay Assembly Showing Location of Particle

Figure 3. Magnified View of Particle Between Armature and Pole Piece

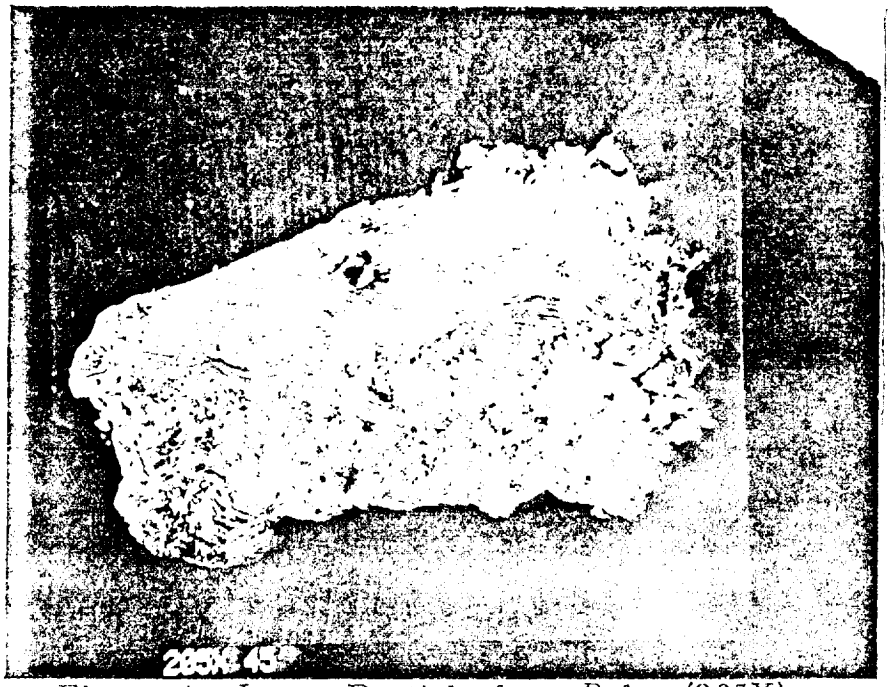


Figure 4. Large Particle from Relay (205X)

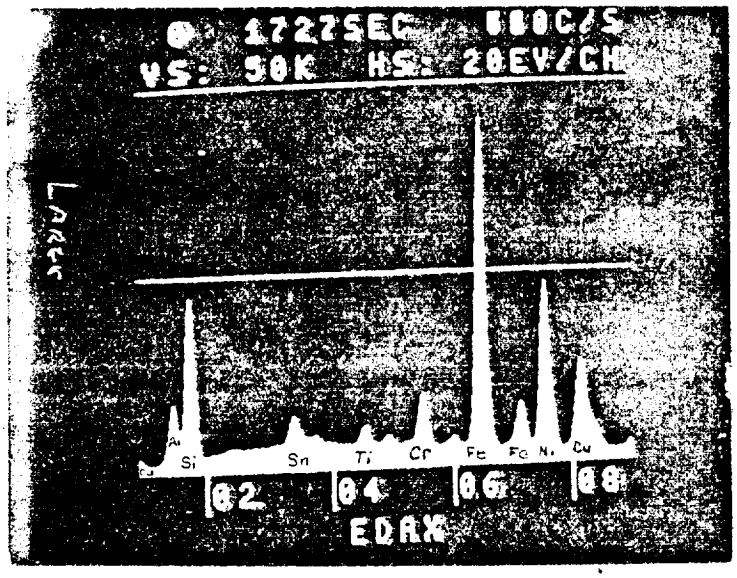


Figure 5. EDAX Analysis of Large Particle

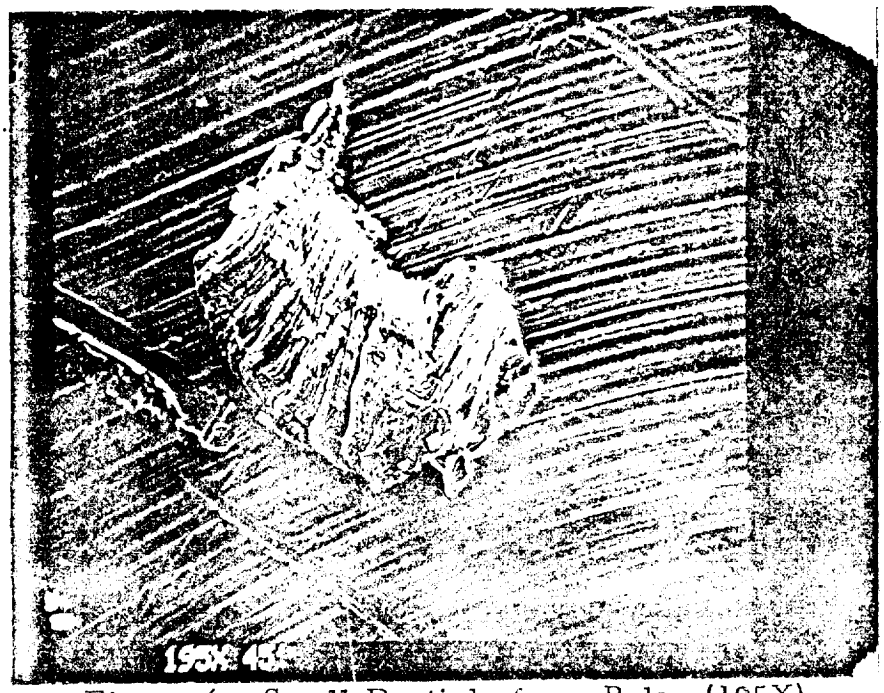


Figure 6. Small Particle from Relay (195X)

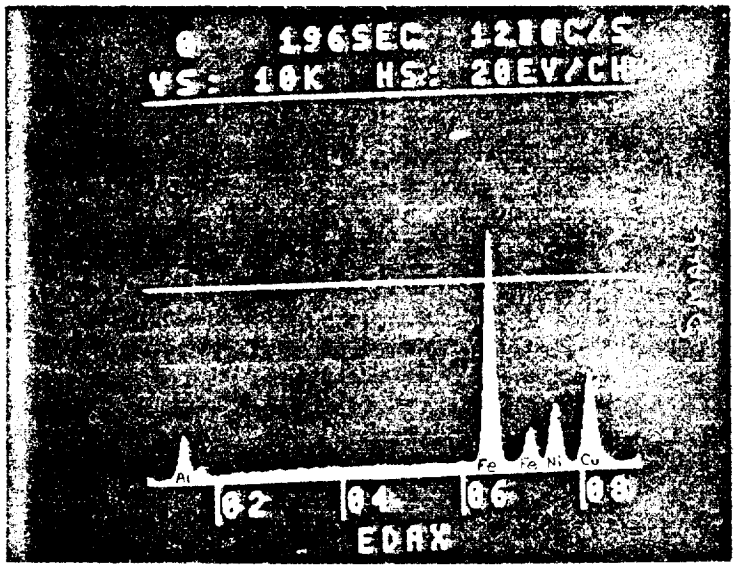


Figure 7. EDAX Analysis of Small Particle

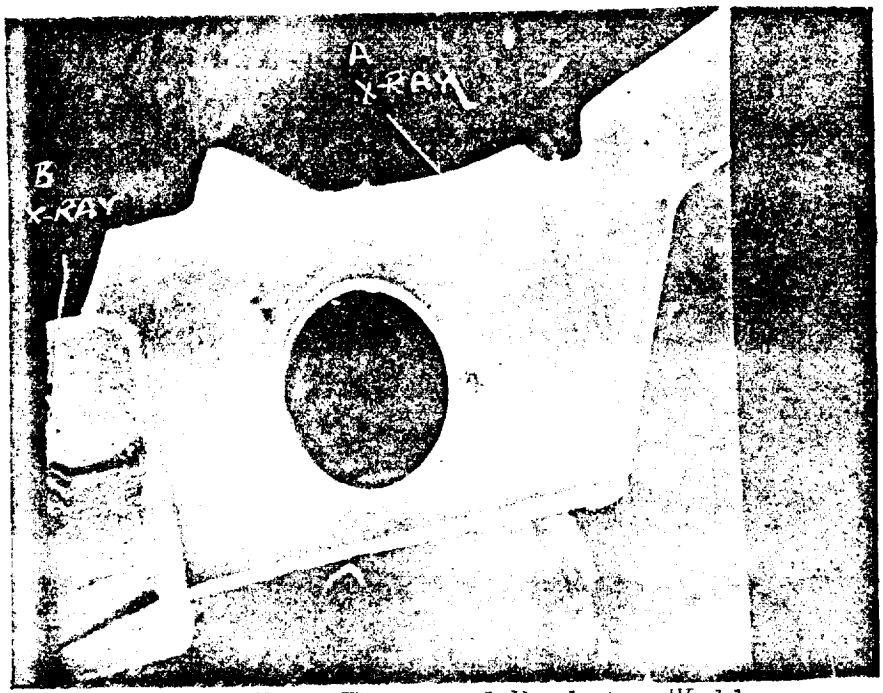


Figure 8. Pole Piece and Backstop Weld Connection

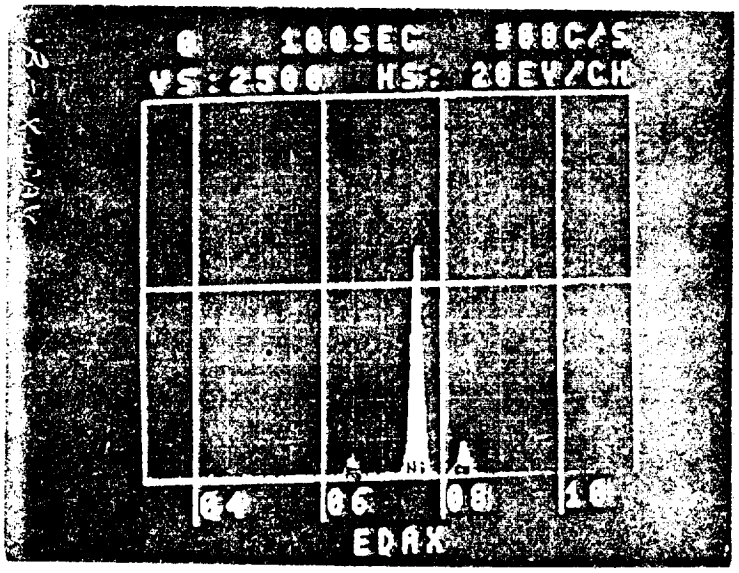


Figure 9. EDAX Analysis of Pole Piece

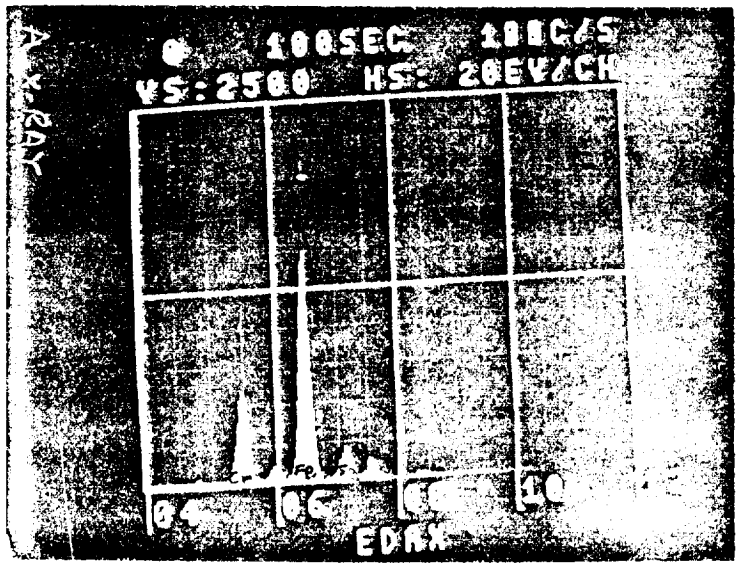


Figure 10. EDAX Analysis of Backstop

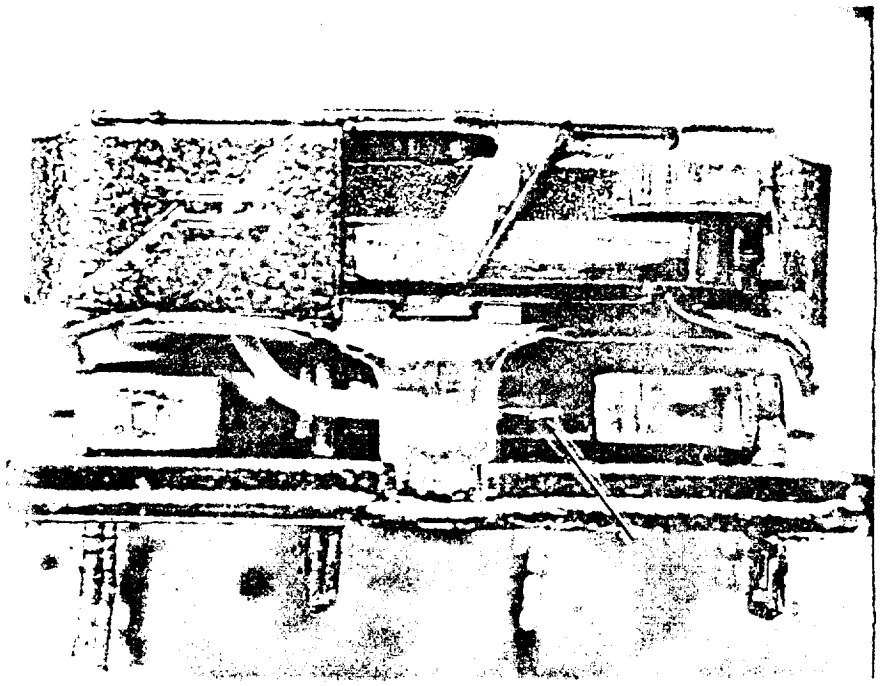


Figure 11. Relay Assembly Showing Coil Lead Pin 19 Missing

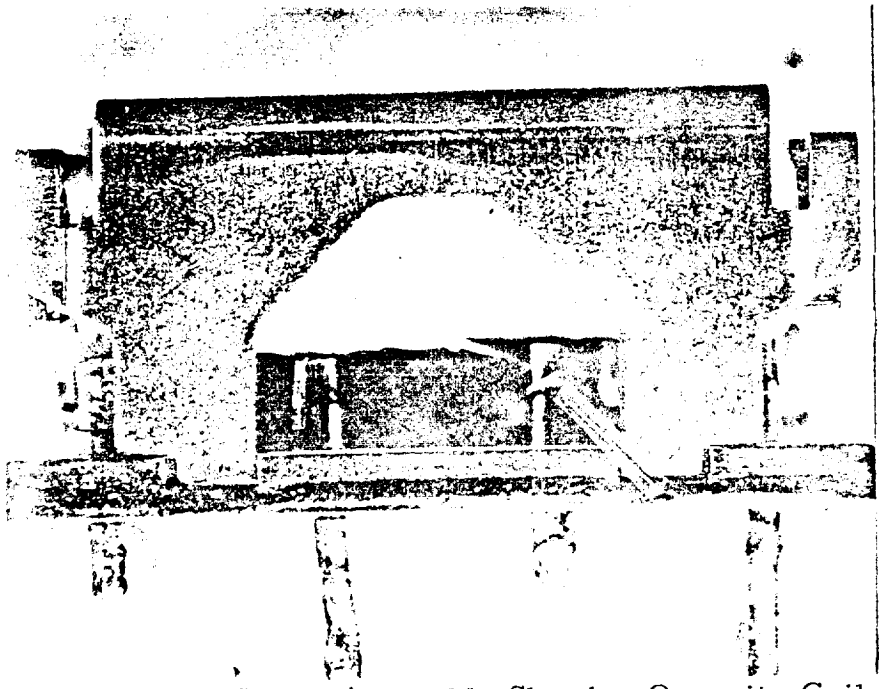


Figure 12. Relay Assembly Showing Opposite Coil Lead Pin 20 Intact

Figure 13. Pin Contact Area of Coil Lead (230X) (Pin 19)

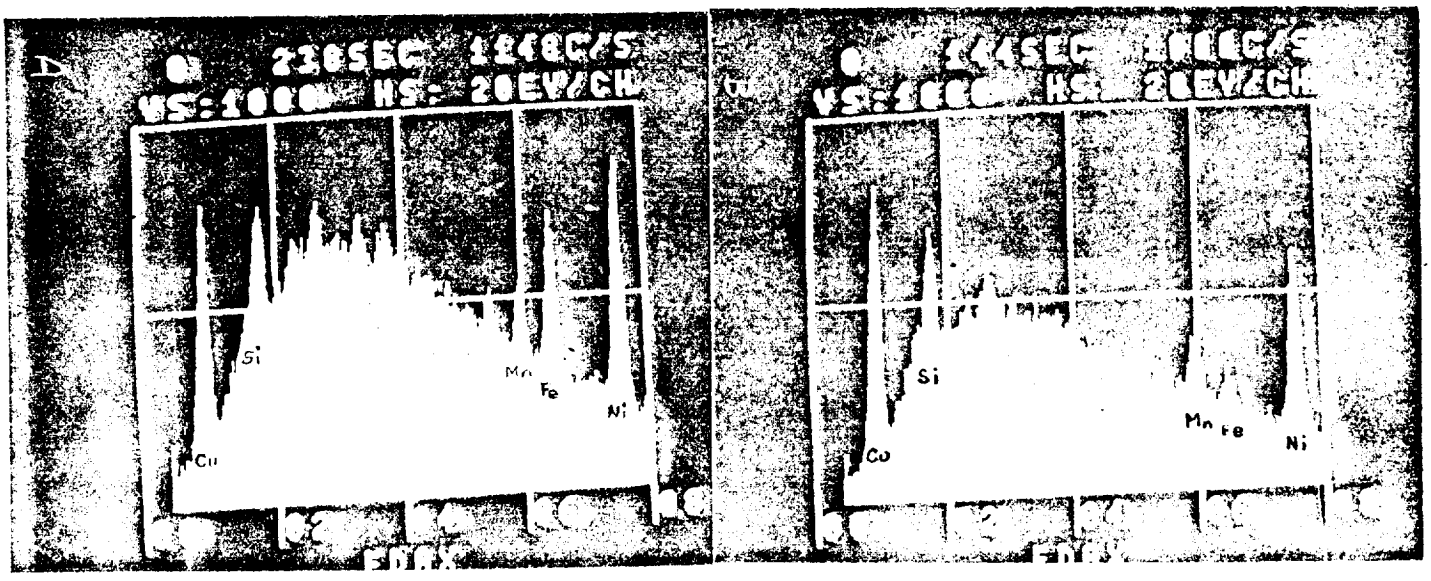


Figure 14. EDAX Analysis of Coil Lead at Pin Contact Area (Pin 19)

Figure 15. Coil Lead on Back Side of Pin Contact Area (150X) (Pin 19)

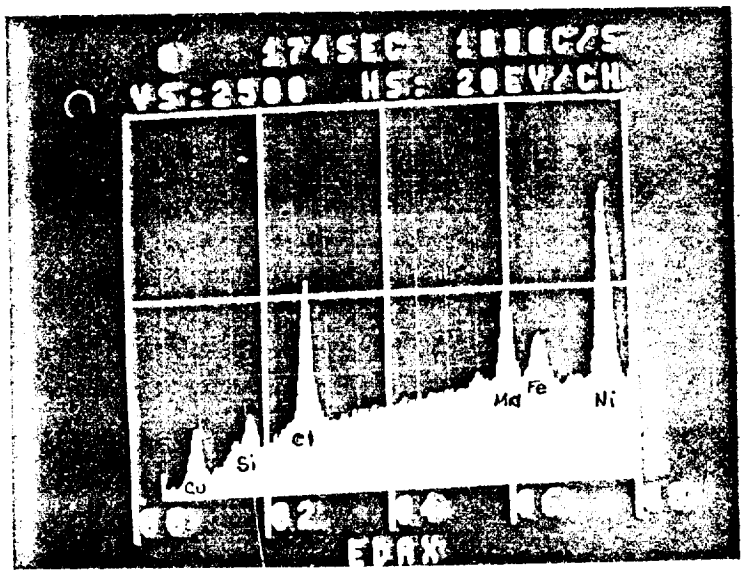


Figure 16. EDAX Analysis of Coil Lead on Back Side of Pin Contact Area (Pin 19)

Figure 17. Pin Showing Lack of Weld Penetration (24X) (Pin 19)

Figure 18. Pin of Opposite Coil Lead (50X) (Pin 20)

Figure 19. Coil Lead Weld of Pin 20 (95X)

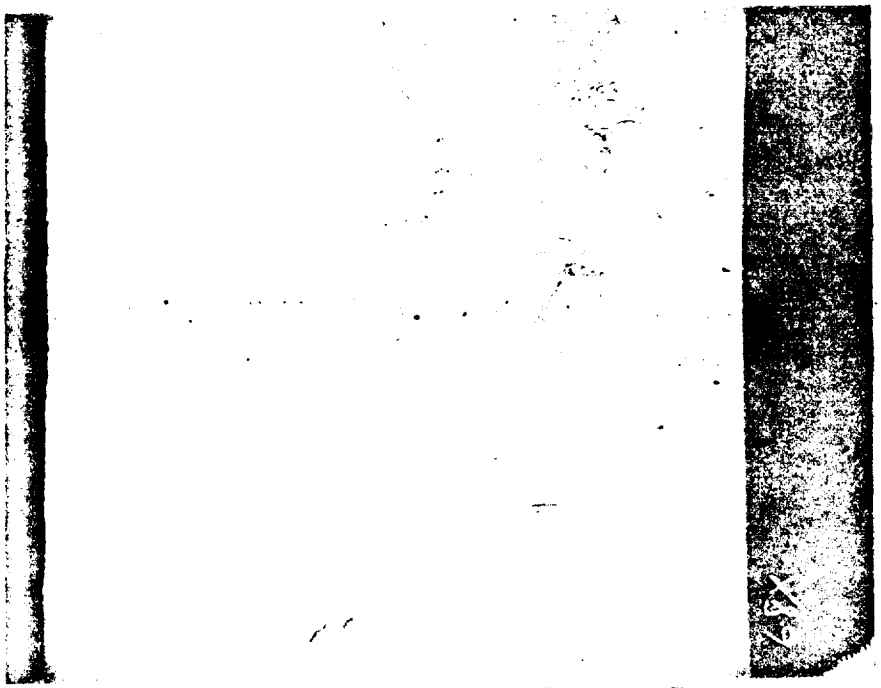


Figure 20. Inside Corner of Case of Relay, S/N 10, Showing Scracthes (68X)

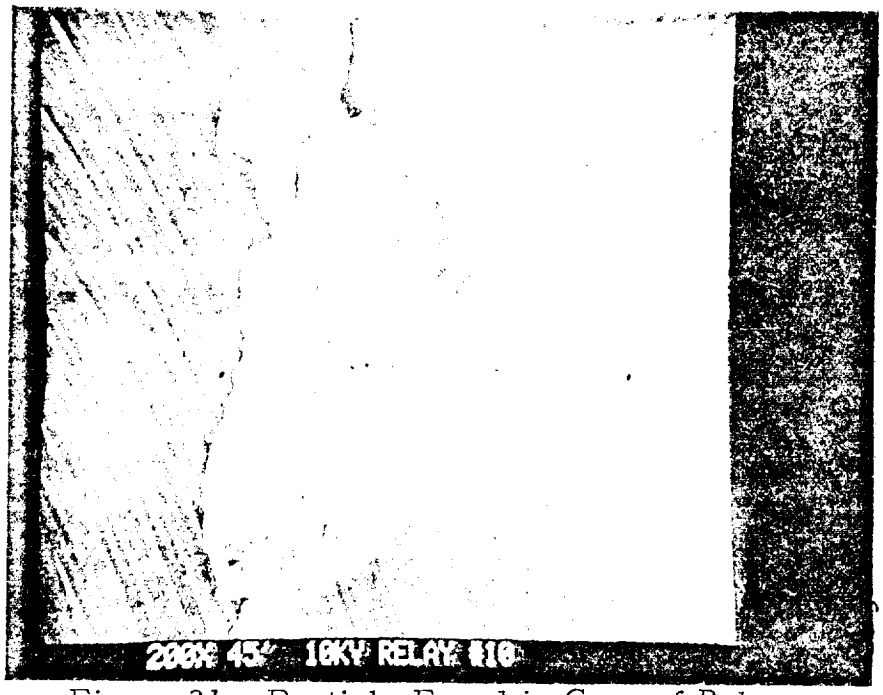


Figure 21. Particle Found in Case of Relay, S/N 10 (200X)

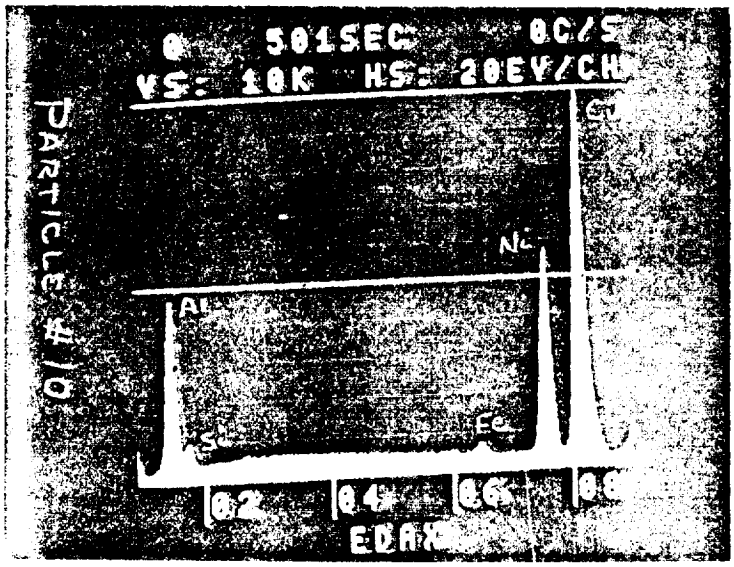


Figure 22. EDAX Analysis of Particle from Relay, S/N 10

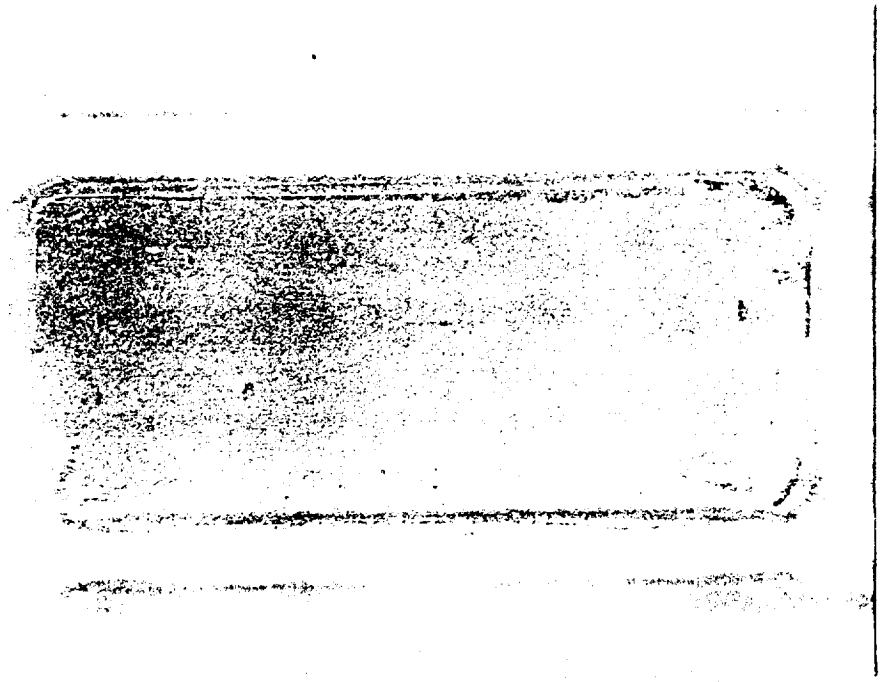


Figure 23. Inside Top of Case of Relay, S/N 22, Showing Residue Spots and Small Particles

Figure 24. Relay, S/N 22, Assembly Showing Round Particle Attached to Armature

Figure 25. Particle from Relay, S/N 22, Armature

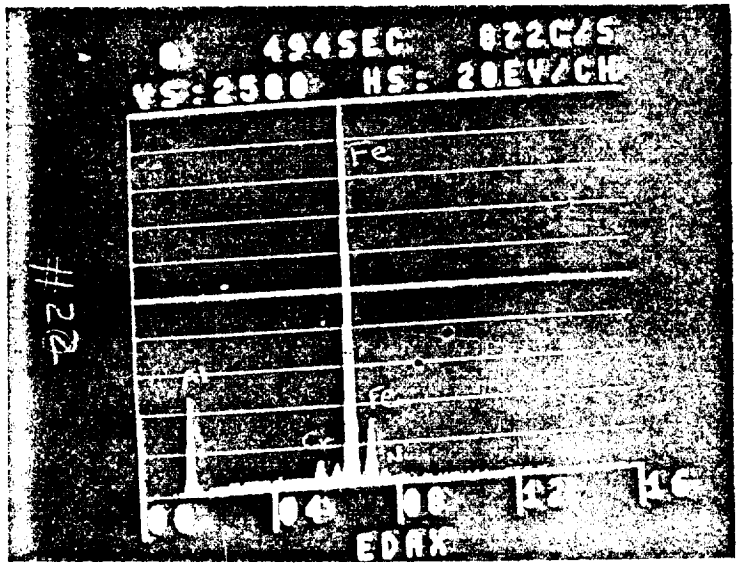


Figure 26. EDAX Analysis of Particle from Relay, S/N 22, Armature

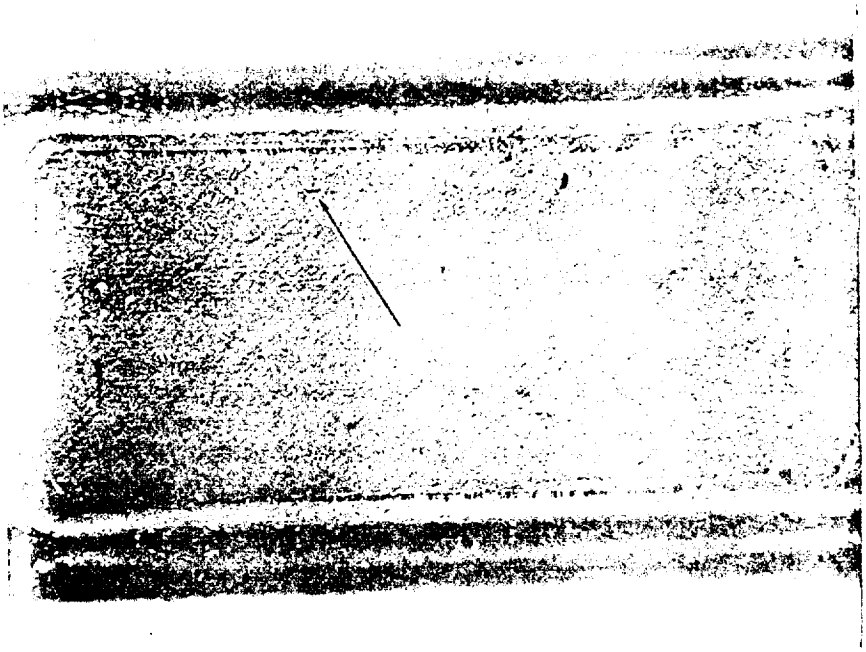


Figure 27. Inside Top of Case of Relay, S/N 24, Showing Copper Colored Particle and Other Small Particles

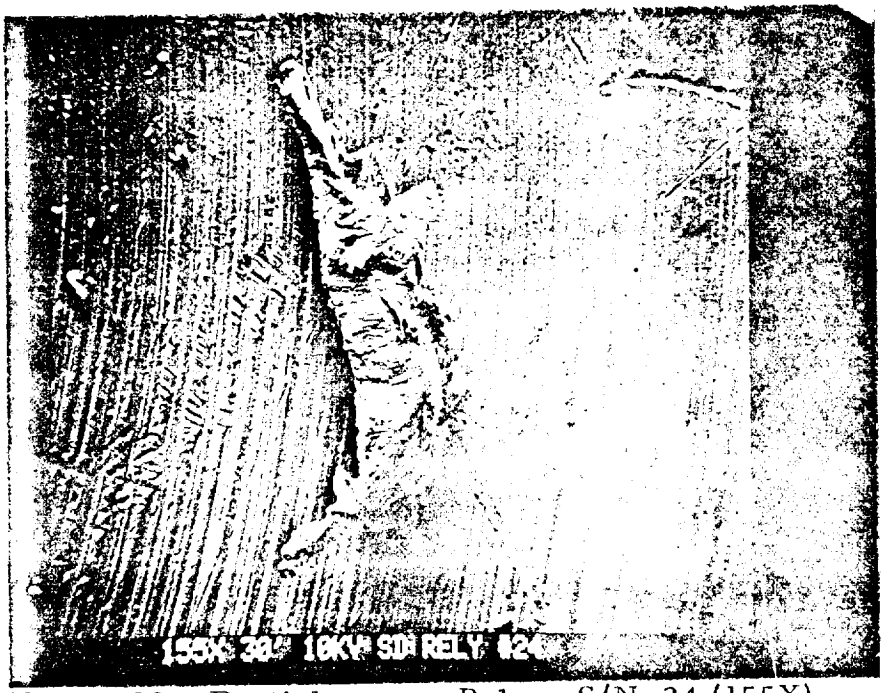


Figure 28. Particle from Relay, S/N 24 (155X)

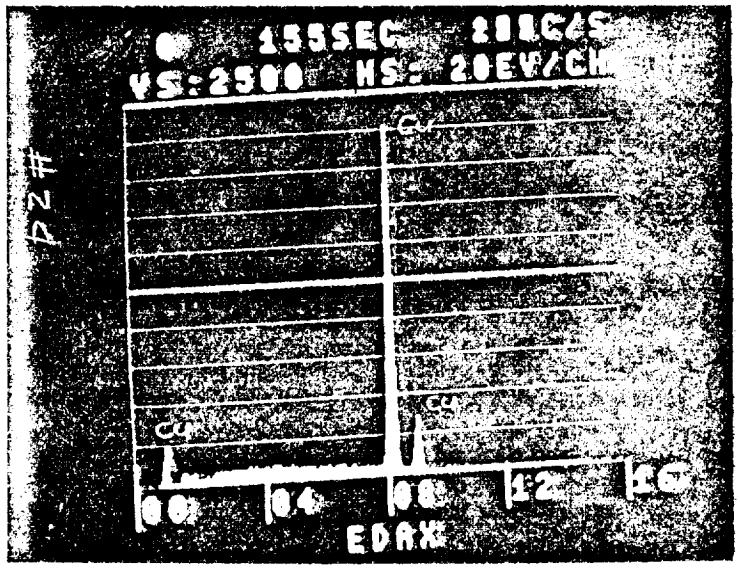


Figure 29. EDAX Analysis of Particle from Relay, S/N 24

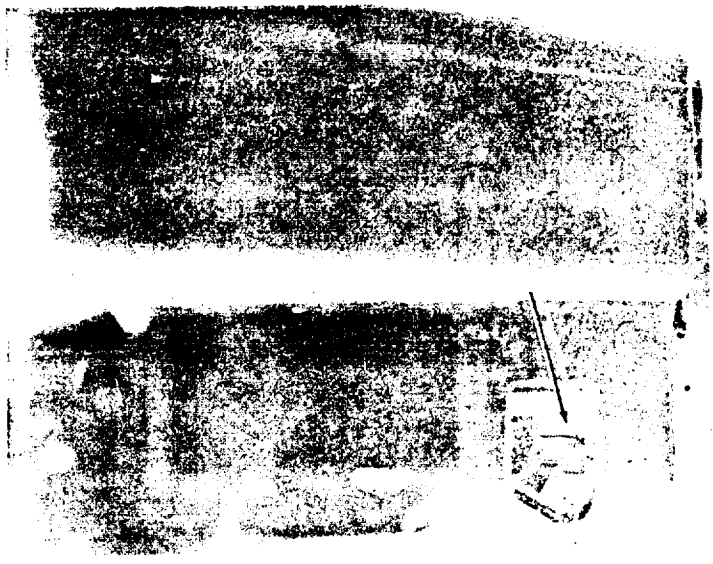


Figure 30. Relay, S/N 24, Assembly Showing Magnetic Particles on Pusher

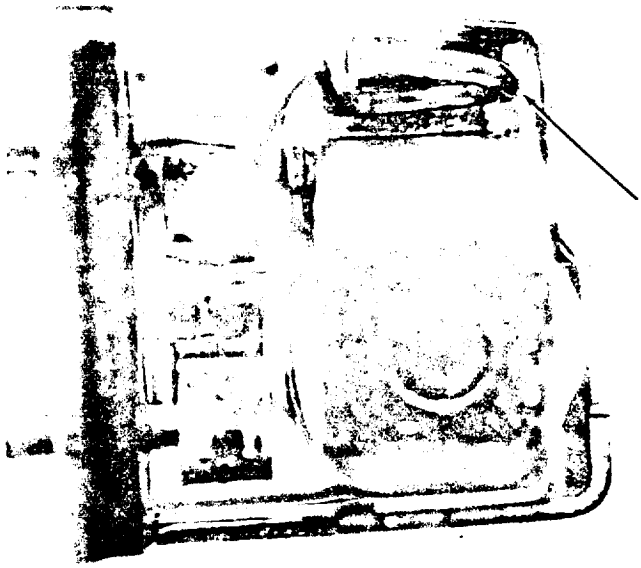


Figure 31. Relay, S/N 20, Assembly Showing Magnetic Particles on Pusher

Figure 32. Inside Top of Case of Relay, S/N 45, Showing Numerous Fibrous Particles and Other Smaller Particles

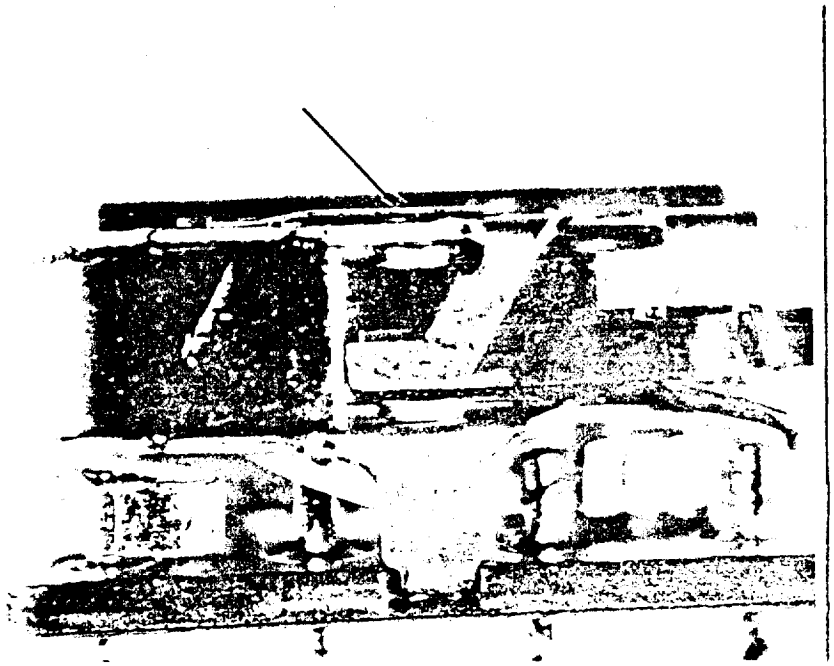


Figure 33. Relay, S/N 45, Assembly Showing Lack of Pivot Bearing Spring Contact and Excessive Armature Pivot Bearing End Play